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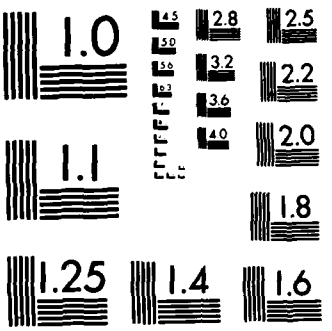

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Experimental measurements of low frequency preamplifiers show that a Type LM394 bipolar input stage has less internal input noise than the popular PAR-113 commercial amplifier for source resistances under 1000 ohms. A Type 2N6483 JFET design shows similar input noise to the PAR-113. The input current noise of the JFET design is insignificant compared with the Nyquist noise of the source resistance.

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TECHNICAL REPORT NO. 2

INTERNAL NOISE OF LOW-FREQUENCY PREAMPLIFIERS

by

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15 August 1983

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ABSTRACT

Experimental measurements of low frequency preamplifiers show that a type LM394 bipolar input stage has less internal input noise than the popular PAR-113 commercial amplifier for source resistances under 1000 ohms. A type 2N6483 JFET design shows similar input noise to the PAR-113. The input current noise of the JFET design is insignificant compared with the Nyquist noise of the source resistance.

It is important to experimentally determine the internal noise levels of preamplifiers used in low-level measurement, because the internal noise limits the sensitivity of these devices. Two low noise preamplifiers were designed and evaluated in comparison with the Princeton Applied Research PAR-113, a commonly used commercial low noise amplifier. One preamplifier uses a LM394 bipolar junction transistor pair input stage to provide low input voltage noise. The second preamplifier uses a 2N6483 JFET pair to provide low input current noise. these transistor types are among the lowest noise transistors presently available for low frequency applications.

The LM394 preamplifier schematic is shown in figure 1. The LM394 is used as a low noise buffer for a standard instrumentation amplifier.[1] The LF353 operational amplifier was selected because of its availability and low noise. The bandpass is 3 Hz to 100 Khz, and may be extended at low frequencies by increasing the emitter capacitors. The upper frequency cutoff is the maximum obtainable with a flat frequency response at an overall voltage gain of 1000. The common mode rejection ratio was measured to be 66 db at 60 Hz.

A low input current noise preamplifier was constructed by replacing the input transistors in Figure 1 with a 2N6483 JFET pair. The emitter and coupling capacitors were omitted to form a DC amplifier. The gate resistors were set at 10 Megaohms to provide a high input impedance. Several minor changes were made for stability and DC offset adjustment. The common mode rejection ratio was measured to be 105 db at 60 Hz.

The input noise of these preamplifiers is determined by the noise of the buffer transistors. These preamplifiers show virtually the lowest noise possible using presently available transistors.

The input noise was characterized by measuring the input voltage noise and the input current noise for each preamplifier.[1] The measured input noise is shown in Figure 2. The input voltage noise of the 2N6483 JFET preamplifier is similar to the PAR-113. The input current noise of the 2N6483 preamplifier and the PAR-113 is negligible for source resistances under 10 Megaohms. The input voltage noise of the LM394 preamplifier is 20 db lower than the PAR-113; however, the input current noise of the LM394 becomes significant for source resistances greater than 100 ohms.

The preamplifiers are most easily compared by examining the total input noise as a function of source resistance. The PAR-113 has the lowest input noise for source resistances greater than 1000 ohms. The LM394 preamplifier shows up to 20 db lower noise than the PAR-113 for source resistances under 1000 ohms. the 2N6483 preamplifier has similar input noise to the PAR-113 for source resistances under 10 Megaohm.

For source resistances over 1000 ohms, the PAR-113 was shown to be the lowest noise preamplifier presently available. In applications with source resistances lower than 1000 ohms, low noise bipolar junction transistors provide significant improvement over the PAR-113. This work was supported in part by the Office of Naval Research.

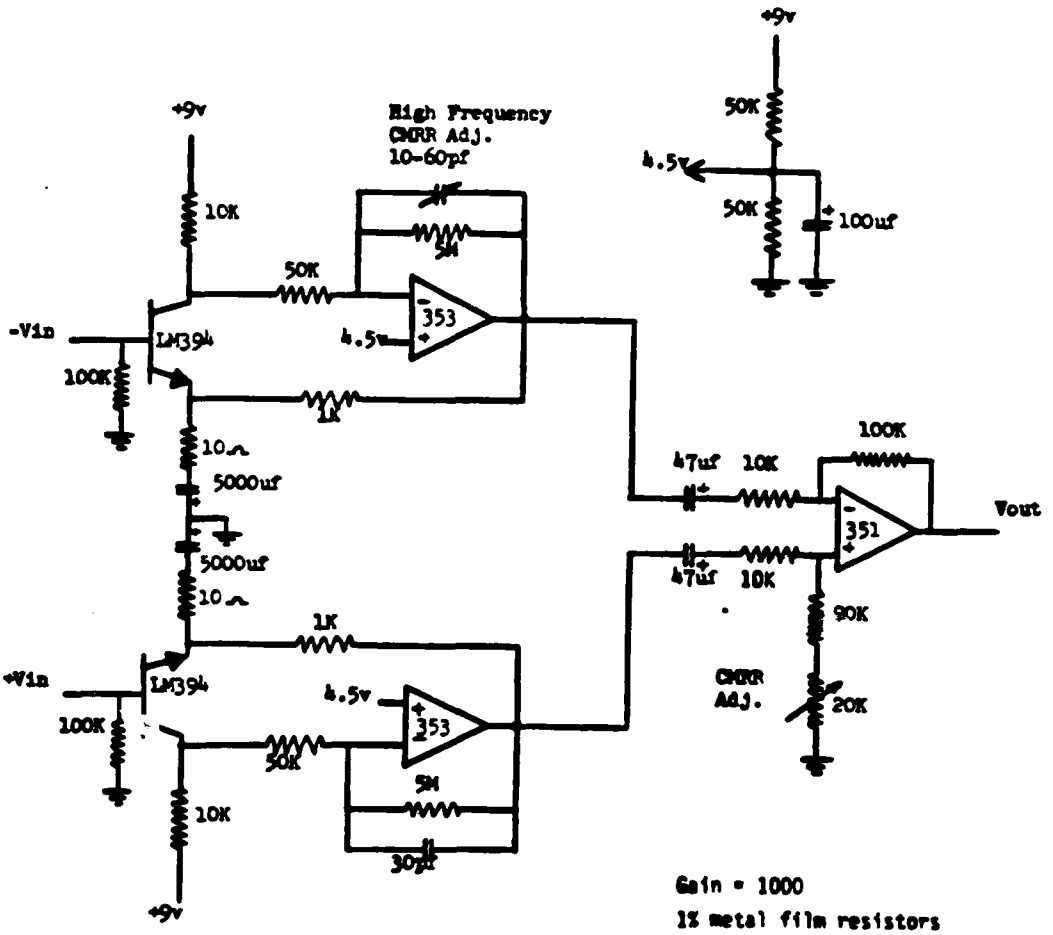
REFERENCES

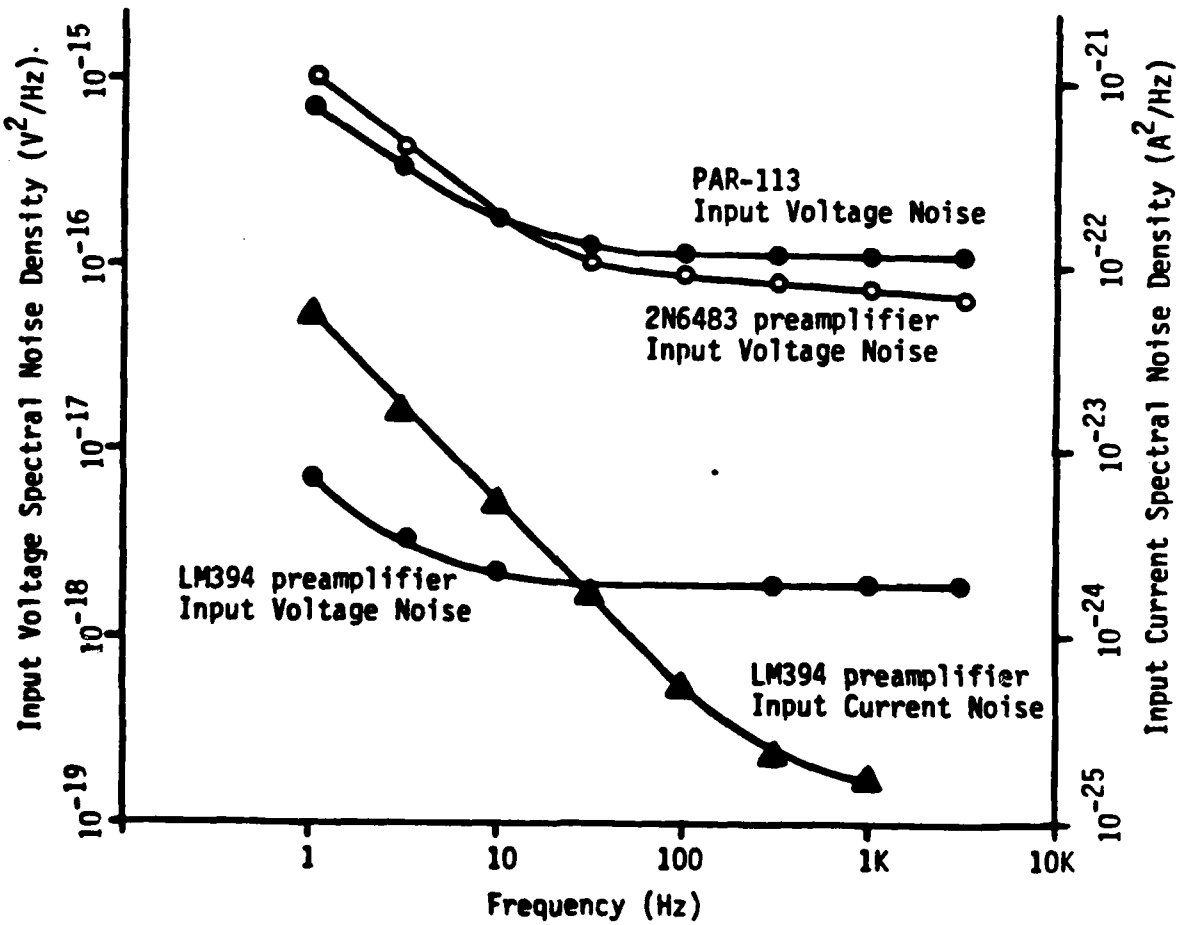
1. P. Horwitz and W. Hill: "The Art of Electronics", Cambridge University Press, New York, 1980.

FIGURE CAPTIONS

Figure 1. Low noise preamplifier schematic

Figure 2. Measured input noise.


+9v
High Frequency
CMRR Adj.
10-60pf
10K
5M
50K
353
-Vin
LM394
4.5v
100K
1K
10
5000uf
5000uf
10
1K
+Vin
LM394
4.5v
353
100K
50K
5M
10K
30pf
+9v
Ic = 450um
+9v
50K
4.5v
50K
100uf
100K
47uf
10K
351
Vout
47uf
10K
90K
CMRR
Adj.
20K
Gain = 1000
1% metal film resistors
Op amps powered by +/- 9 volts


Input Voltage Spectral Noise Density (V^2/Hz)
10^{-15}
10^{-16}
10^{-17}
10^{-18}
10^{-19}
Input Current Spectral Noise Density (A^2/Hz)
10^{-21}
10^{-22}
10^{-23}
10^{-24}
10^{-25}
PAR-113
Input Voltage Noise
2N6483 preamplifier
Input Voltage Noise
LM394 preamplifier
Input Voltage Noise
LM394 preamplifier
Input Current Noise
1
10
100
1K
10K
Frequency (Hz)

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